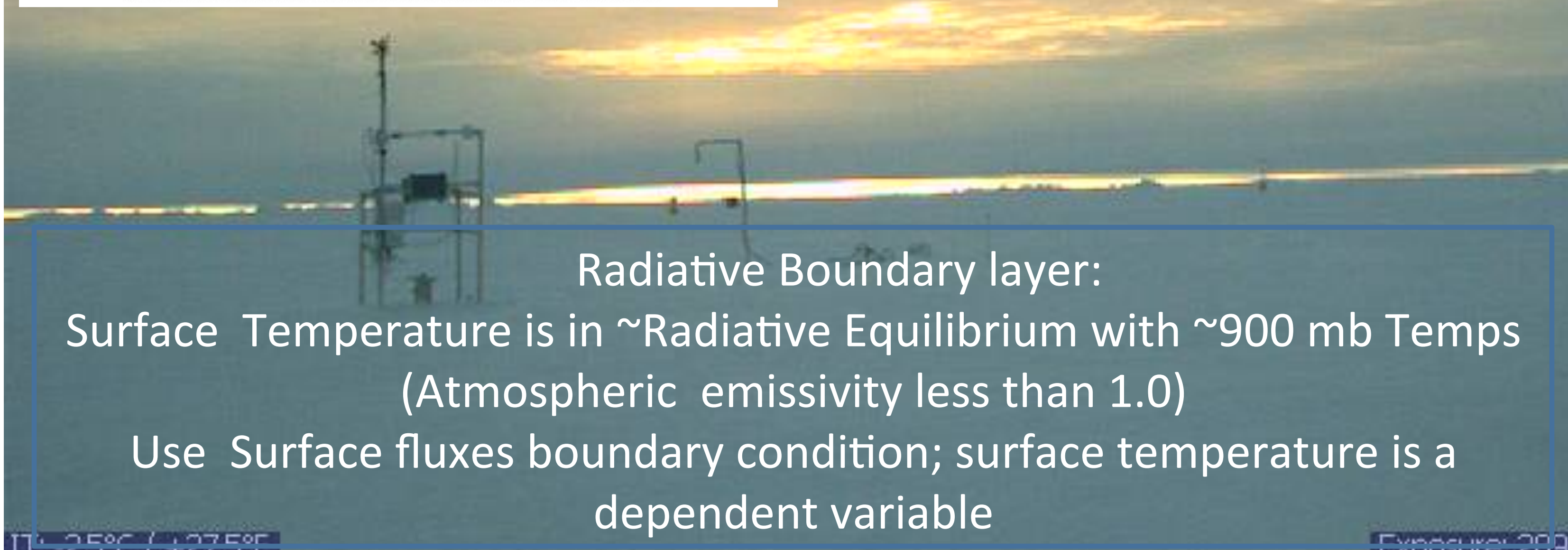
Polar Boundary Layers

- Radiative Boundary layer, not a Convective Boundary layer
- Heterogeneous Surface
- Geostrophic Drag Coefficients



4658 OVERLAND AND GUEST: ARCTIC SNOW AND AIR TEMPERATURE BUDGET

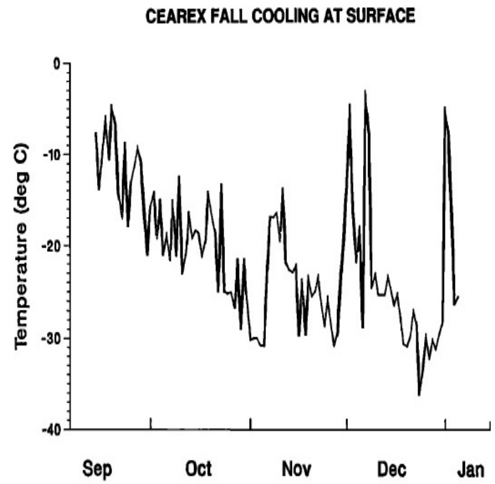


Fig. 12. Plot of air temperature of 0000 UT every day during the CEAREX drift. The thermometer was located on the bow mast of the R/V *Polarbjorn* at an elevation of 14 m. Winter cooling occurred by early November, followed by an alternation of clear and cloudy periods which correspond to high and low surface temperatures.

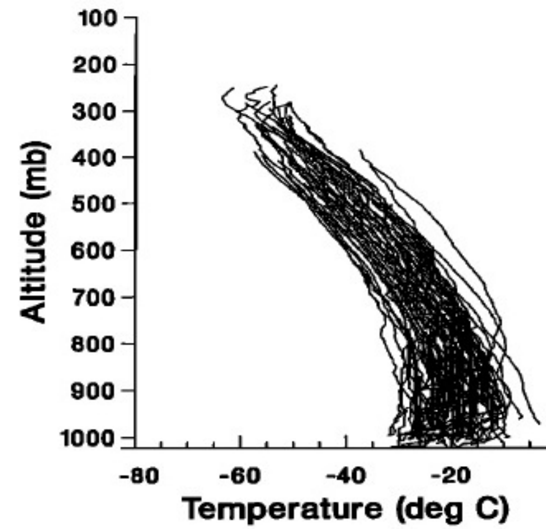


Fig. 13. Plot of 0000 UT temperature soundings obtained throughout the CEAREX drift.

Radiative Boundary layer:

Surface Temperature is in ~Radiative Equilibrium with ~900 mb Temps (Atmospheric emissivity less than 1.0)

Use Surface fluxes boundary condition; surface temperature is a dependent variable

Upward sensible heat flux over 3% leads balances Downward sensible flux over ice

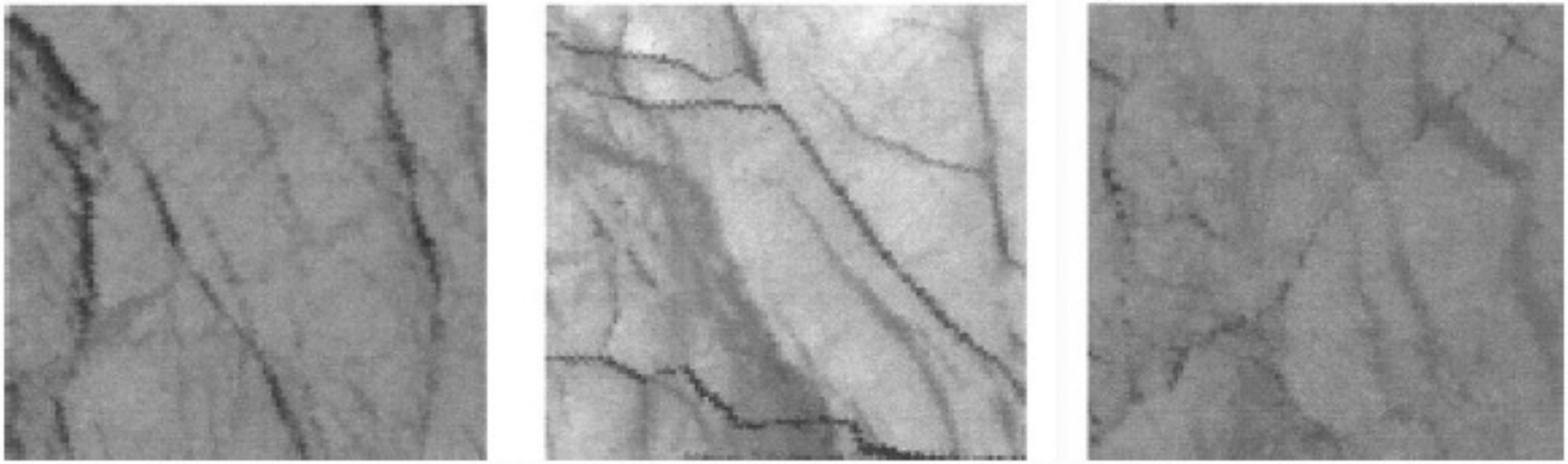


Figure 2. Each square shows 100 × 100 AVHRR pixels centered on the SHEBA camp location for (a) December 10, 1997, (b) January 16, 1998, and (c) February 20, 1998 (see Figure 1). Each pixel is ~1 × 1 km².

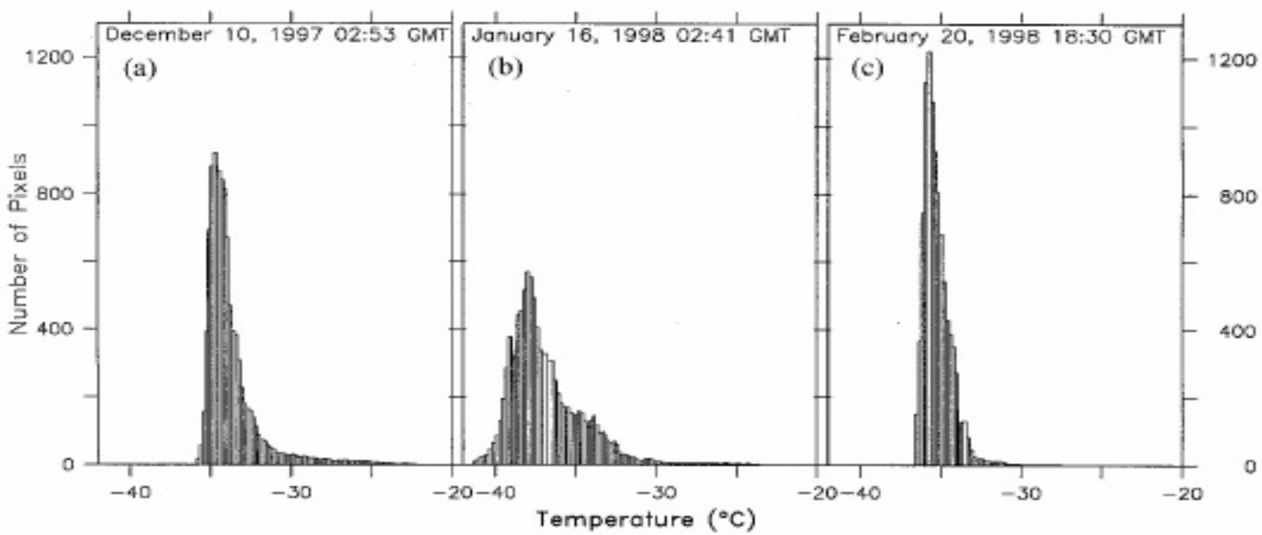


Figure 3. Temperature histograms taken for single AVHRR images from Figure 2.

TABLE 2. Summary of Drag Coefficients Derived From Tower Measurements Taken Over Large, Flat Ice Floes

Data Set	Reference	Location and Date	$10^3 C_D$	Comments
1	*Untersteiner and Badgley* [1965]; *Ling and Untersteiner* [1974]	Beaufort 1957–1958	1.24	uniform old ice, lead and pressure ridge 500 m away, large scatter which was independent of season
2	*Doronin* [1969, p. 11]	Arctic November 1955	1.73	Severnyi polyus 5, 5 level tower
3		August 1956	1.58	Severnyi polyus 4
4	*Banke and Smith* [1973]	Beaufort April 1971	1.14	AIDJEX pilot floe 2, $T_a < -22°$, smoothly hummocked ice floe
5	*Banke et al.* [1976]	Beaufort April 1975	1.38	AIDJEX, flat ice, $T_a < -12°$, strong reduction with stability
6	*Leavitt* [1980]	Beaufort 1975–1976	1.24	AIDJEX, very smooth floes, strong reduction with stability
7	*Banke et al.* [1980]	Beaufort March 1976	1.33	AIDJEX, $T_a < -16°$
8	*Smith* [1972]	Gulf of St. Lawrence March 1970	1.4	first year, smooth for several kilometers, $T_a \sim -3°$ to $-9°$
9	*Seifert and Langleben* [1972]	Gulf of St. Lawrence March 1970	1.7	first year, same site as *Smith* [1972]
10	*Langleben* [1972]	Coastal Beaufort April–May 1971	1.68	first year, flat, unbroken, $T_a < -15°$
11	*Joffre* [1982*a*]	Gulf of Bothnia	1.40	first year, large 2-km floe,
12		March–April 1977	1.55	$T_a < -5°$, strong winds, strong reduction with stability
13	*Banke and Smith* [1973]	Beaufort April 1971	1.7	AIDJEX pilot, $T_a < -22°$
14		Beaufort	1.8	AIDJEX pilot, $T_a < -16°$
15		April 1972	1.9	
16	*Langleben and Pounder*	Beaufort	1.58	AIDJEX pilot
17	[1975]	April 1972	1.74	

More than one entry for a reference refers to measurements from different floes. T_a is air temperature. Wind speed reference level is 10 m.

TABLE 5. Summary of Drag Coefficients Computed From Momentum Balance and Measurements Made From Aircraft

Data Set	Reference	Location	$10^3 C_D$	Method	Comments
33	*Brown* [1974]	Arctic March 1972	2.8	momentum integral	1972 AIDJEX, $Z_i = 80$ m, $Z_* = 10$
34	*Carsey* [1980]	Arctic 1975–1976	2.7	momentum integral	AIDJEX, $Z_i = 125$ m, $Z_* = 14$
35	*Katz* [1979]	Arctic February 1976	2.6	aircraft	AIDJEX, $T_a < -30°$, $Z_i = 80$ m, $\zeta_* = -0.1$, $Z_* = 40$
36	*Katz* [1980]	Arctic July 1975	1.7	aircraft	$T_a = 0°$, $Z_i = 80$ m, $\zeta_* = +0.4$, $Z_* = 18$
37	*Joffre* [1983*a*]	Gulf of Bothnia	2.31	momentum integral	$Z_i = 200$ m, $T_a \sim -5°$, $Z_* = 10$, larger than form drag
38		March–April 1977	1.96		estimates
39	*Pease et al.* [1983]	Bering Sea March 1981	2.9	drag plate	$C_i = 0.9$, $T_a < -3°$, $Z_i = 300$ m, $\zeta_* = -1$, $Z_* = 15$
40	*Walter et al.* [1984]	North Bering Sea February 1982	3.0	aircraft	$C_i = 0.88$, $T_a = -20°$, $Z_i = 660$ m, $\zeta_* = -1.1$, $Z_* = 9$
41	MIZEX-West	Bering Sea February 1983	2.9	aircraft	$C_i = 0.98$, $T_a = -11°$, $Z_i = 260$ m, $\zeta_* = -1.0$, $Z_* = 13$
42			2.5		$C_i = 0.97$, $T_a = -11°$, $Z_i = 290$ m, $\zeta_* = -0.6$, $Z_* = 13$
43			3.1		$C_i = 0.90$, $T_a = -13°$, $Z_i = 150$ m, $\zeta_* = -0.4$, $Z_* = 21$
44	MIZEX-1984	Greenland Sea outer MIZ June 1984	2.2	aircraft	$C_i = 0.44$, $T_a = -2°$
45	*Andreas et al.* [1984]	Antarctic outer MIZ October 1981	2.88	turbulent energy equation	$C_i = 0.3$, $T_a - T_s \cong 0°$, $Z_i = 690$ m, $\zeta_* = +400$, $Z_* = 4$

Wind speed reference height is 10 m, C_i is ice concentration, T_a is air temperature, T_s is water temperature, and Z_i is inversion height. Except for aircraft case studies, Z_* estimates are typical values for the duration of the study period.

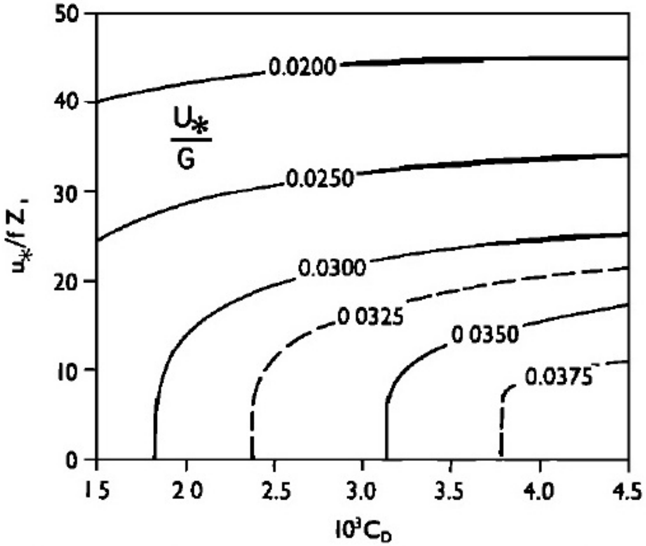


Fig. 9. Second-order closure model results showing dependence of the geostrophic drag coefficient u_*/G on $Z_* = u_*/fZ_i$ and C_D. $G = 12.5$ m/s.

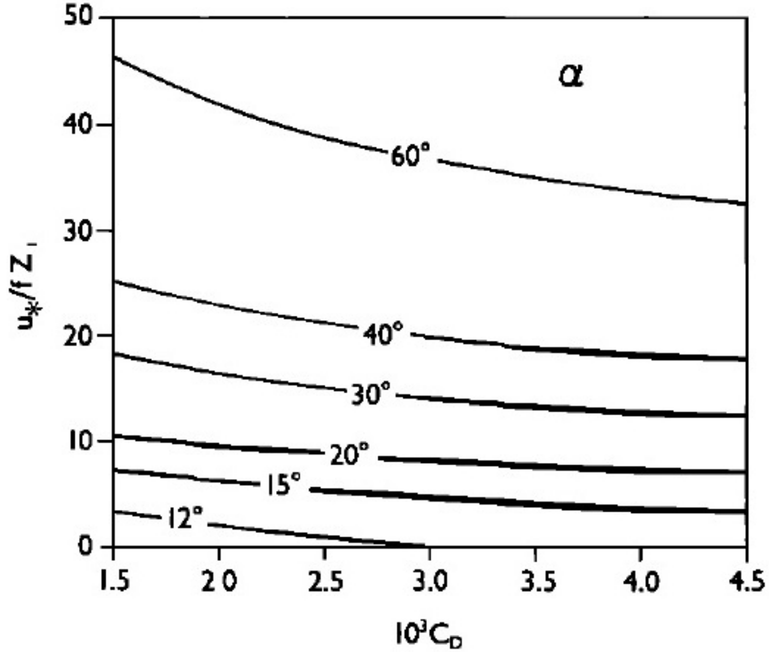
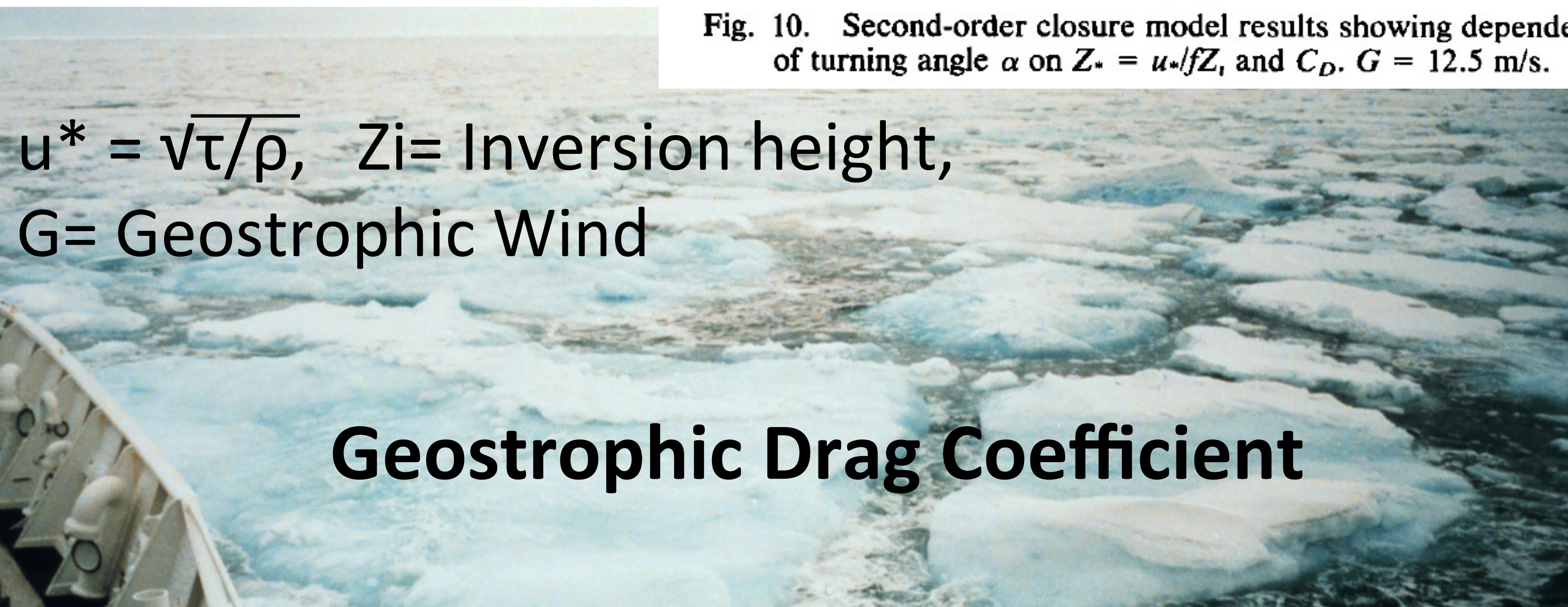


Fig. 10. Second-order closure model results showing dependence of turning angle α on $Z_* = u_*/fZ_i$ and C_D. $G = 12.5$ m/s.



$u^* = \sqrt{\tau/\rho}$, Zi= Inversion height,

G= Geostrophic Wind

Geostrophic Drag Coefficient